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# Equality Requirements for Software Systems: A Survey

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**Abstract**—In order to support social sustainability through software systems, we must learn to engineer requirements that foster sustainability conditions within a society. Yet, the notion of social sustainability is very complex, encompassing equality, trust, cultural and religious diversity support, community participation and more. In this paper we present results of a survey-based study on the notion of equality within a range of software users. Do diverse users converge to some common views on equality? Does the diversity of users itself influence these perceptions. And can we formulate requirements statements for these perceptions? We explore these questions through analysis of data from 155 (relatively well educated, English speaking, and technologically literate) survey respondents.

**Index Terms**—Social sustainability; software; requirements engineering; equality, survey.

## I. INTRODUCTION

A society is *socially sustainable* if it has a sound basic framework that *supports its members cooperation at low transaction costs* [1]. Shared values, equal rights, and community, religious and cultural interactions are necessary components of such a framework [1]. What this really means, is that in a socially sustainable society individuals and groups interact (e.g., trade, borrow and lend, innovate, learn, govern, and regulate, etc.) with the maximum personal and social benefit and minimum expenses, lost opportunities (e.g., due to discrimination or corruption, etc.) or discomfort, i.e., with *minimum transition costs*.

As software mediates more and more activities in the modern societies, many software engineering researchers argue that it also has a key role to play in supporting social sustainability. Thus, some researchers [2], [3] argue that values drive decision making in software engineering. Consequently, these values would be embodied within software implementations and would drive the way that software operates and structures social interactions around itself. Similarly, Becker et al. [4] note that sustainability values should be explicitly and intentionally engineered as requirements into software requirements specifications, and subsequently implemented in the resultant software systems.

Indeed, several pieces of research demonstrate how to integrate environmental sustainability concerns into software system, e.g., by reducing resource consumption, and fostering reuse [5], [6], or improve technical sustainability of software

assets by increasing their longevity [7]. Yet, at present very little work has been published on how to engineer social sustainability through software [8]. Given that, as noted above [1], social sustainability encompasses a large set of complex characteristics (e.g., from cultural to religious and community interactions, governance and trust) tackling this challenge would require addressing a single social sustainability characteristic at time. Thus, in this paper we explore the equality characteristic of social sustainability.

The key contributions of this paper are two-fold, as it explores:

- If there is an overall agreement across the wider software user community on what requirements are relevant for engineering equality through software, and
- If demographic characteristics of individuals are correlated with their perceptions of the relevance of the software equality requirements.

To realise the above two contributions, the paper first discusses related work to equality and its support through software in section II. Then presents an overview of how a number of equality requirements statements (which a software system should enforce) have been identified from several previously and independently specified software requirements documents. Using these requirements statements, the present research has developed a survey instrument, which has been used for data collection and analysis that help us deliver the said contributions. The research methodology used in this survey design and analysis is detailed in section III. The results are presented in section IV, with threats to validity discussed in section V. The paper is concluded with section VI.

## II. EQUALITY REQUIREMENTS

Equality is defined as the right for all members in a society to enjoy living and getting access to services and facilities without being discriminated because of their origin, beliefs, position, or (dis-)abilities [9]. It is an internationally advocated value that several standards and acts endeavour to instill. For instance: (i) the ISO 26000 [10] aims at helping organisations to install such principles as gender equality and fair treatment; (ii) Social Accountability Standard 8000 [11] states guidelines on child labour, forced or compulsory

labour, health and safety, freedom of association and collective bargaining, discrimination and alike; (iii) Equality Act 2010 [12] aims at reducing socioeconomic inequalities, harmonising equality laws and tackling discrimination and harassment due to individuals' personal characteristics.

Equality is often considered from two seemingly contradictory positions:

- one (let's call it *equal equality*) taking the viewpoint that since all members of a society should be equal, they must all receive the same treatment and equal access to resources [13]. If anyone is not treated equally, it raises unfairness complaints.
- the other (which we'll call *unequal equality*) interpretation [13] suggests that since members of society differ, equality means providing different treatments to accommodate the diversities of groups and individuals. Here, "... failing to provide different treatment is itself unequal because of the unequal social and economic position of different groups. . . . in this position, diversity enhances equality by ensuring that unequals are treated differently and unequally."

A number of researchers take the *equal equality* view and discuss equality in terms of *equal resource allocation* e.g., for equal water [14] and housing [15] resource distribution between members of society. They stand for removing race, age, religious [16] and gender [16], [17] discrimination, as well as inequalities due to geographical location of society members. The infrastructural access inequalities [18] could be reduced by enabling equal *access* to electronic resources [18], as well as improving access to community (e.g. child care) and social (e.g. cultural events) infrastructure [15].

When ICT is concerned, Web Content Accessibility Guidelines (WCAG) [19] aim to ensure that web content is accessible, supports equal access and opportunity for people with disabilities [20], older users, people in rural areas and developing countries.

Those who advocate the *unequal equality*, argue that equal distribution does not always entail fairness and it is *fair*, rather than *equal distribution* and access to resources that is essential for social sustainability [14]. Thus, those with greatest need should be provided with more resources (e.g., babies should get more milk than adults), those who invest more should get more back [21] (e.g., if one individual works twice as hard as the other, she should get twice as much pay), etc.

While each of the above equality-related viewpoints have valid philosophical grounds, we, as software engineering researchers, are interested in establishing if there are common requirements that could be used for engineering equality through software systems. Thus, we adopted a pragmatic approach aimed at identifying equality requirements statements relevant to software systems, as detailed in the following section.

### III. RESEARCH METHODOLOGY

In order to elicit how the software users perceive equality requirements for software systems, we chose to collect data through a survey [22]. We followed survey design and analysis guidelines devised by Kitchenham and Pfleeger [23] and Van Sellem [22].

The key objectives of this study are three-fold:

- to discern a prioritised ranking of requirements related to equality, as perceived by the general software user community;
- to investigate the effect of such demographic factors as users' expertise, education, gender and religion on their perception of given equality requirements;
- to observe if there is an overall agreement on what constitutes equality within the general software user community.

#### A. Eliciting Equality Requirements Statements

To construct a survey, we first needed to identify equality requirements statements relevant to software systems. For this we applied the equality requirements pattern and template proposed in [24] on software systems requirements specification documents<sup>1</sup> which were developed previously by independent requirements engineers from across a variety of application domains. Most of these documents were selected as they have been previously used as benchmarks in other requirements and software engineering-related studies by other researchers. The documents are sourced from reputable research or software practitioner organisations, are written in English and well structured.

A number of recurring equality-related requirements statements were identified. These are general statements that are applicable to different software system. This was done to avoid users' familiarity problem with a specific software system or domain. It is worth noting that we do not claim that the statements listed in Table I are the complete and full requirements for the realisation of equality concern; this simply is a relevant sub-set obtained through application of the equality value patterns method [24] to a set of requirements documents.

These requirements statements were combined with a few additional statements, that do not directly relate to equality (as presented in Table I and discussed in section III-B) and were used for a survey-based study to observe the perceptions of the software users on equality and relevance of equality requirements.

#### B. Survey Design

A cross-sectional survey instrument was designed for the data collection purposes [23]. As we were interested in general

<sup>1</sup>These documents are: [14], [16], [25], [26], [17], [27], [28], [29], [30], [31], [15]

software users' perspectives, with varying demographics factors (including religion), we chose to utilise an online survey [22] format (to fill it the respondents will clearly need to use software), which was distributed widely through different communities and lists.

The online survey comprised an information sheet (with a participation consent form to be confirmed by the respondents), followed by three self-administered data collection sections.

Section 1 of the survey consisted of 21 previously selected requirements statements (as discussed in section III-A and summarised in Table I). Here the respondents were asked to evaluate the importance of each of the given statements for its' relevance as a software system's equality requirement. The relevance was indicated as *irrelevant (NAI)* (see Table I, for statements that do not relate to equality), *neither relevant nor irrelevant (Table I, NINU)* to indicate the respondent's indecision or lack of knowledge on the relevance of a given statement, and *relevant*, where relevance was subcategories into *slightly relevant (SI)*, *relevant (IE)*, and *very relevant (VIE)* options.

Because this is an importance scale, we did not aim to produce balanced levels. Knowing that a statement is not important to equality is more relevant than knowing the degree or depth of unimportance. In the case of unimportance, the direction is what we are looking for and not the depth. On the other hand, knowing the degree of importance can help requirements engineers to prioritise equality requirements and decide which should be included in the first release and which to be kept for later releases taking into consideration resource availability (e.g. time, money, skills, etc.). In this case, "discrimination . . . between the positive scale positions" is important [32].

To identify how well the respondents distinguish the notions of equality from other requirements relevant to social sustainability, we mixed into the survey a set of statements that did not relate to equality. These are statements 1, 4, 5 and 17 in Table I where:

- statement 1 is a security requirement;
- statement 4 is a performance requirement;
- statement 5 is a robustness requirement;
- statement 17 is an availability requirement.

Section 2 of the survey consisted of two questions aimed to explicitly elicit the respondents' notion of equality in terms of priorities they give to software profitability, usability, functionality, and equal goal support for various user groups. Here data was collected in multiple choice options with nominal scale.

Section 3 of the survey comprised of 6 questions for collection of demographic information. This section was partly adopted from the survey by Osho et al. [33]. Here the questions aimed to both help characterise the sample of the participating respondents, and to elicit what effect the demographics have

on the priorities and perceptions of equality. The survey was concluded with a brief thank you note.

The first version of the survey was piloted with a small set of participants. The pilot helped to identify and rectify a number of concerns. Here the wording of the information sheet was amended, several grammatical mistakes were corrected, and the demographic information section was moved from the beginning to the end of the survey. Thereupon, the final version of the survey was published through a web survey tool<sup>2</sup>.

#### C. Population and Respondent Sampling

Since we are interested in the views of the general software users (i.e., anyone who uses any kind of software), the targeted population of this study is potentially counted in more than millions<sup>3</sup>, with a similarly large numbers of *online* software users [34]. This lead us to choosing sampling methods that reach a diverse range of respondents and communities. Thus, the *unrestricted sampling* [22] and *convenience sampling* [23] methods were used by publicising the survey questionnaire through LinkedIn, Instagram, Facebook, Twitter, ResearchGate and WhatsApp.

Additionally, invitation emails were sent to the students and staff list at the University of Leicester, UK, and, through academic colleagues, at other counties (such as USA, Brazil, Germany, and Oman). To encourage varied religious backgrounds representation, we also explicitly reached out to colleges from Omani universities through randomly selected staff members emails available online, asking them to distribute the participation request locally. As we requested that the colleagues and respondents forward the participation request to all who they considered may have been willing to respond to the survey, we also incorporated elements of *snowball sampling* (which is also an unrestricted and convenience sampling method) [23] into the data collection.

#### D. Data validation and analysis

We consider a response valid if all the set questions have been completed. Clearly, any respondent would have completed the survey through use of software, and this (i.e., software use experience) was the only fundamental qualifying constraint for participation in this survey. Thus all completed responses would be valid.

To analyse the data, we used frequency analysis to describe the importance of the equality requirements statements as well as inferential statistical analysis methods to discern the influence of demographic factors on the equality perceptions.

### IV. DISCUSSION OF FINDINGS

Below we first describe the set of our respondents in terms of their demographic characteristics, then address the above stated study objectives on equality requirements prioritisation, perceptions, and influence of the elicited demographic factors upon these.

<sup>2</sup><https://www.onlinesurveys.ac.uk>

<sup>3</sup><http://chrisniderdesign.com/blog/resources/social-media-statistics/>

TABLE I. Requirements Statements (\* marks non-equality related entries)

Requirements Statements	
S1*:	User authentication is important for supporting equality.
S2:	Usability of software to users from different age ranges is important to support equality.
S3:	Suitability of software to users from different age ranges is important to support equality.
S4*:	Short response time to user enquiry is important for supporting equality.
S5*:	Short recovery time after system failure is important for supporting equality.
S6:	Suitability of software to users from different genders is important to support equality.
S7:	Considering direct stakeholders' goals behind using a software is important to support equality.
S8:	Fairly selecting which goals will be implemented in the software is important for supporting equality.
S9:	Ability to accommodate new types of users is important for supporting equality.
S10:	Multilingual interface is important for supporting equality.
S11:	Different information presentation formats (e.g., audio, video, text) is important for supporting equality.
S12:	Compatibility of software application with different operating systems is important for supporting equality.
S13:	Compatibility of software application with different hardware devices is important for supporting equality.
S14:	Availability of software's usage guidance (e.g., help, tutorials, and tips) considering users with no/little prior knowledge of this software is important for supporting equality.
S15:	Availability of software's shortcuts to accomplish tasks for experts and fast learners is important for supporting equality.
S16:	Availability of software application on different web and mobile platforms is important for supporting equality.
S17*:	Availability for use 24 hours per day, 365 days per year is important for supporting equality.
S18:	Allowing stakeholders to equally access software services to achieve their goals is important for supporting equality.
S19:	Suitability of software for users from different religious beliefs is important for supporting equality.
S20:	Accepting information from different media (e.g., voice, text, braille) is important for supporting equality.
S21:	Considering indirect stakeholder goals that are affected by the software is important for supporting equality.

#### A. Respondents profile

The respondents' sample was nearly evenly balanced for gender, with a slightly higher female participation (by 1.2%), as illustrated in Table II. The average age of the participants was 37, with the age characteristic also well distributed in 18 to 64 years old range, but only one over 65 year old participant. The vast majority of participants were in employment or education (see Table II). Only 1.9% of the respondents were novice software users and the majority (45.8%) were of an advance proficiency (as per Table II).

The largest group (just over a half) of the respondents report to be of Muslim background, which could have arisen due to the previously mentioned more direct invitation of Omani participants. Christians and Hindus are the next two larger religious groups (see Figure 1).

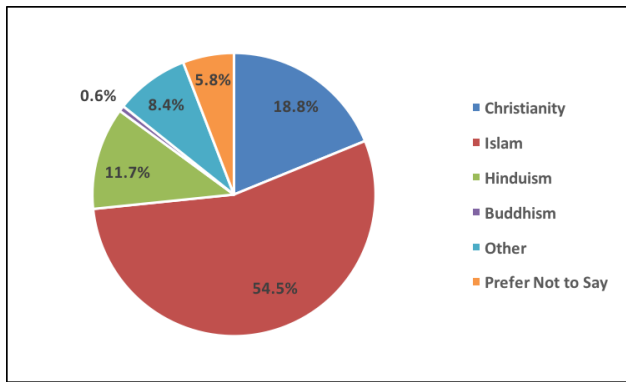


Fig. 1. Respondents Religion, N = 154

The highest education level of the respondents is rather biased towards the highly qualified end, with 34.2% holding

PhD and 36.1% Masters degrees (see Table II). There were no unschooled respondents. Thus, our sample is clearly biased towards highly educated software users. This, in itself, is not entirely surprising, as the topic of the survey (software and equality) as well as method of data collection already presumes some minimum education and technological literacy levels.

#### B. Frequency of Equality Statements

The ordering of the responses on the priority of equality statement for software systems is summarised in Table III and demonstrated in Figure 2 with a divergent stacked bar [35].

As Figure 2 shows, statements S10: Multilingual interface, S14: Software's usage guidance (e.g., help, tutorials, and tips), S11: Different information presentation formats (e.g., audio, video, text), S20: Different input support formats, and S3: Support for users across various ages, are the highest ranked overall relevant statements (i.e., highest combined slightly relevant, relevant, and very relevant). All these statements also have consistently low irrelevance and indecision ranking. Which clearly indicates that there is an agreement (though not unanimous) across the respondents that these statements are closely related to equality.

Similarly, respondents have consistently marked out the deliberately introduced unrelated statements (i.e. S1, S4, S5 and S17) as both the least relevant, most irrelevant, and the most doubted (i.e., neither relevant, nor irrelevant) subset. However, here too, the respondents were not unanimous in their ratings, as some respondents have ranked S17 as having something to do with equality. S17 is a statement on software availability and may have been perceived as tangentially relevant to equality by providing users with access at time of their convenience, without restrictions. Despite these discrepancies,

TABLE II. Respondents Profile

Background		No (Valid %)
Gender	Male	76 ( 49)
	Female	78 ( 50.3)
	Undisclosed	1 ( 0.65)
Age	18 to 24 years	21 (13.5)
	25 to 34 years	40 (25.8)
	35 to 44 years	57 (36.8)
	45 to 54 years	29 (18.7)
	55 to 64 years	7 (4.5)
	Age 65 or older	1 (0.6)
Employment	Employed	115 (74.2)
	Student	36 (23.2)
	Unemployed	4 (2.6)
	Retired	0 (0)
Highest level of education	PhD (or equivalent)	53 (34.2)
	Masters Degree (or equivalent)	56 (36.1)
	Undergraduate (or equivalent)	24 (15.5)
	A college degree (diploma and equivalent)	21 (13.5)
	High school degree or less	1 (0.6)
Level of software use proficiency	Novice	3 (1.9)
	Intermediate	28 (18.1)
	Advanced	71 (45.8)
	Expert	53 (34.2)

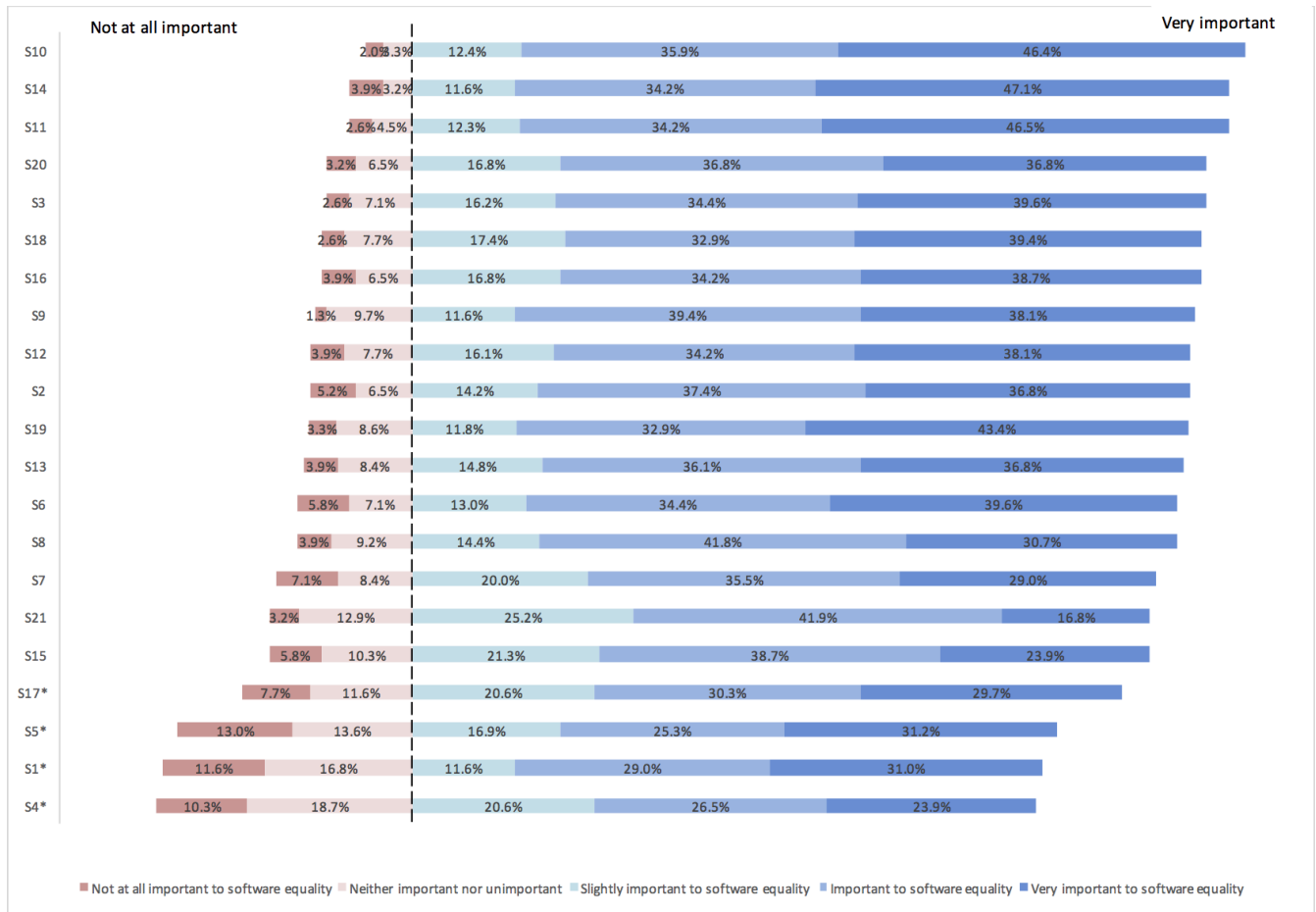


Fig. 2. Statements ranks

the overall correct and consistent ranking of the least relevant statements, indicates that there is a general agreement among the survey respondents on the statements that do not relate (or weakly relate) to equality.

Considering the topic ranking, for the genuinely equality-related statements list (i.e., with exclusion of S1, S4, S5 and S17) we note that the highest importance is attributed to statements supporting interaction of the users with the software

TABLE III. Statements Frequencies

Statement	NAI	NINU	SI	IE	VIE
S1* (sec)	18 (11.6%)	26 (16.8%)	18 (11.6%)	45 (29.0%)	48 (31.0%)
S2	8 (5.2%)	10 (6.5%)	22 (14.2%)	58 (37.4%)	57 (36.8%)
S3-1	4 (2.6%)	11 (7.1%)	25 (16.2%)	53 (34.4%)	61 (39.6%)
S4* (per)	6 (10.3%)	29 (18.7%)	32 (20.6%)	41 (26.5%)	37 (23.9%)
S5-1* (rob)	20 (13.0%)	21 (13.6%)	26 (16.9%)	39 (25.3%)	48 (31.2%)
S6-1	9 (5.8%)	11 (7.1%)	20 (13.0%)	53 (34.4%)	61 (39.6%)
S7	11 (7.1%)	13 (8.4%)	31 (20.0%)	55 (35.5%)	45 (29.0%)
S8-2	6 (3.9%)	14 (9.2%)	22 (14.4%)	64 (41.8%)	47 (30.7%)
S9	2 (1.3%)	15 (9.7%)	18 (11.6%)	61 (39.4%)	59 (38.1%)
S10-2	3 (2.0%)	5 (3.3%)	19 (12.4%)	55 (35.9%)	71 (46.4%)
S11	4 (2.6%)	7 (4.5%)	19 (12.3%)	53 (34.2%)	72 (46.5%)
S12	6 (3.9%)	12 (7.7%)	25 (16.1%)	53 (34.2%)	59 (38.1%)
S13	6 (3.9%)	13 (8.4%)	23 (14.8%)	56 (36.1%)	57 (36.8%)
S14	6 (3.9%)	5 (3.2%)	18 (11.6%)	53 (34.2%)	73 (47.1%)
S15	9 (5.8%)	16 (10.3%)	33 (21.3%)	60 (38.7%)	37 (23.9%)
S16	6 (3.9%)	10 (6.5%)	26 (16.8%)	53 (34.2%)	60 (38.7%)
S17* (av.)	12 (7.7%)	18 (11.6%)	32 (20.6%)	47 (30.3%)	46 (29.7%)
S18	4 (2.6%)	12 (7.7%)	27 (17.4%)	51 (32.9%)	61 (39.4%)
S19-3	5 (3.3%)	13 (8.6%)	18 (11.8%)	50 (32.9%)	66 (43.4%)
S20	5 (3.2%) )	10 (6.5%)	26 (16.8%)	57 (36.8%)	57 (36.8%)
S21	5 (3.2%)	20 (12.9%)	39 (25.2%)	65 (41.9%)	26 (16.8%)

Note: \* marks statements that are not directly related to equality; S1 relate to security (sec), S4 relate to performance (per), S5 related to robustness (rob), and S17 on availability (av)

(S10, 14, 11, 20), followed by the mixed order of topics related to user variability support (e.g., age, technical platform support, etc.). The statements that support stakeholder goals (S8, 7, 21) come at the bottom part of the list.

Out of 17 genuine equality-related statements, the least importantly ranked was S21 (Considering indirect stakeholder goals) and S15 (availability of softwares shortcuts). This, could be explained with the fact that the key focus of software is normally placed on direct software users, with indirect stakeholders considered thereafter. Clearly, the long-term cumulative effects of a software system could dramatically affect indirect stakeholders. For example, the long-term use of Amazon.com by large number of individuals has gradually undermined many physical retail shops, and their located environments and communities (e.g., empty shops in town centres leading to unattractive social spaces). Yet, normally software users first of all focus on the direct effect of their immediate interaction with the software system (e.g., ability to obtain the desired book at lower price from an online bookstore). This tension between priorities of direct and indirect stakeholders is, indeed, one of the characteristics of social sustainability concerns.

On the other hand, statement S15 might have been rated least relevant because the extra service of supporting experienced users was thought of as more related to usability than equality. It could also be that the extra functionality is viewed as a privilege given only to expert users. However, having extra features to for experts does not hinder novice users from accessing same features in simpler but potentially more time consuming ways.

### C. Equality Goals

As noted before, the questions in section two were aimed at understanding what concerns drive the notion of equality for software systems in the respondents: from profit, to usability, functionality, and user priorities. While Question2<sup>4</sup> asked to make a choice for the key equality-conducive goals, Question3<sup>5</sup> asked which user groups should be supported.

The results indicate that our respondents are relatively equally distributed in prioritising support for specific group goals, provision of same but equal functionality to all users (without distinction), and simple usability of software as the key drivers of enabling equality through software.

For Q2 the largest group of respondents (37.7%) said that to support equality, the most prioritised goals for each group should be integrated into software. This suggests that most respondents consider that equality is supported through looking at the different stakeholders groups and finding the best way of allowing them to achieve their goals through the software system. In Q3 72.4% of this respondent group had consistently noted that goals of different stakeholder groups should be implemented to support equality. Thus, this group of respondents considers *equality as equitable support of various goals of the different user groups* for a given software system.

Another large group of respondents (31.8%) for Q2 said that to them the best way to enable equality through software is by providing same functionality at same level to all user groups. For Q3, the majority (69.4%) of this respondent group

<sup>4</sup>Statement of Q2: To support equality in a given software application, we should implement the goals that

- Deliver the highest profit
- Provide best usable interface
- Provide same level of functionality to all user groups
- Implement the most prioritized goals for each user group.

<sup>5</sup>Statement of Question 3: An online shopping software has several groups of users. Normal users are regular users who use the software to perform basic shopping through the website. Gold users are those who buy expensive products that generate high income for the business. Special users are those who use the application with special request of adjustment to their disabilities (colour blindness, hearing loss, etc.). Each group of users have different goals to be implemented by the online shopping application. To support equality through the online shopping application, which goals will you select to be implemented in the application.

- The normal users goals
- The special users goals
- The normal and special users goals
- The normal and gold users goals
- The special and gold users goals
- All of them

also chose that goals of different stakeholder groups should be supported. Thus, this group considers *equality as delivery of the same service at same level to all user groups* for a given software system.

The third largest group of respondents (27.9%) for Q2 said that provision of the best usable interface is the key driver for equality. In response to Q3, 50.0% of respondents in this sub-group indicated that goals of all user groups should be implemented. It could have been expected that those concerned with the usability of the software would care more about the users with disabilities (who could face more difficulties with the software use). However, only 7.1% from this sub-group indicated the specialist (disadvantaged) user groups as those who should be especially supported via the software system to enable equality.

Furthermore, a small group of respondents (2.6%) considered profit maximisation as a key direction to enable equality in Q2, and for Q3 half of this sub-group chose prioritising requirements of the “gold user” group (i.e., those who buy expensive packages of service for a given software) as the key in achieving equality, while the other half chose to support all user groups.

In summary, while (as found from Q3 responses) the vast majority of respondents (64.7%) think that goals of all user groups should be supported, the perception of the way that equality should be delivered with software system is varied: just over one third of survey respondents noted the need to support goals that each user groups prioritises; another third focused on equal service level to all - whichever service that may be and to whomever it is delivered; and the other (slightly less than) third portion of respondents underlined the usability of software as key to its support for equality.

#### D. Impact of Background Factors

To study what impact background factors may have on the perception of equality, we consider if and how the demographic factors affect both equality goal priorities (i.e., responses to Q2 and Q3) and ranking of equality-related statements.

1) *Impact on Equality Goal Priority:* We start our study of the demographic factors impact by formulating a null hypothesis that the background variables (Q4-9) and equality goals (Q2 and Q3) variables are independent, with the alternative hypothesis that they are indeed dependant:

- $H_0$  : Background variables and equality goals variables are **not related**.
- $H_a$  : Background variables and equality goals variables are **related**.

Given that all variables for respondents background (questions 4 to 9) and equality goals (questions Q2-3) are categorical (i.e., nominal and ordinal), chi-square test would normally be performed [36] to examine the relationships between these variables. However, when a cross-tabulation of these two variables is created, the data contains a high

percentage (more than 20%) of cells with under 5 count. Consequently, the Fisher’s exact test [37] is preferred to the chi-square. Additionally, since the compared variables are at more than 2 categorical levels (e.g., employment status has 4 options: employed, student, unemployed and retired), the Fisher-Freeman-Halton Test<sup>6</sup> was undertaken.

Where the relationships between age factor and Q3’s user group selection was studied, we utilised the Monte Carlo method as an alternative to Fisher’s test (to resolve the issues of high memory intensity posed by the exact tests [38]).

The test results are detailed in Table IV, from which we observe that the probability of dependence between the background variables and goal priorities is negligible for all demographic characteristics but that of software usage proficiency. Thus, the above stated  $H_0$  hypothesis has to be accepted for the majority of demographic characteristics (where p-value is over 0.05 as per Table IV), but rejected for the software usage proficiency factor.

Thus, we observe that in our sample of respondents, the decision on which groups’ goals should be implemented (as per Q3) in a software system to support equality is related to respondents proficiency in software usage:

- Half of the novice respondents said that equality would be achieved by supporting goals of all types of user groups, but the other half thought that support of the “gold users” goals would lead to better equality.
- The majority of the intermediate, advanced and expert users considered that goals of all types of groups should be supported (37.0%, 70.4% and 71.7% respectively).

This could be explained by more experienced users having had more opportunities to participate in software system use as part of different groups (e.g., service provider or consumer (e.g., seller and buyer), viewer, support team member, developer, or an administrator, etc.). We expect that such an experience of broader exposure would, naturally, underline the relevance of multiple groups of system users (though presently we do not have sufficient data to substantiated this causality opinion).

2) *Impact on Statement Rating:* Inference analysis for the role of the background factors on the rating of the statements not-related to equality (i.e., S1, 4, 5, 15, 17) shows that the rating of the statements 1, 17 and 15 is not affected by the background factors of the respondents. However, we observe a relationship between religion of the respondents and their rating of the statements for S4: Response time and S 5: Recovery time (at p-value = 0.047 which is under 0.05 for S4 and p-value = 0.008, which is under 0.01 for S5).

Many Muslims participants (31.0%) rated statement 4 as **very important** to equality. Many Christian (24.1% ) and Hindu (44.4%) participants found it **important to equality**, and a large number of those with other beliefs (38.5%) rated this statement as **slightly important** to software equality. Finally, many of the respondents who did not disclose their

<sup>6</sup><http://www-01.ibm.com/support/docview.wss?uid=swg21479647>



TABLE IV. Equality Goals and Background Factors

Background factor	Equality Goal	Results	Interpretation
Gender	Q2	FET=1.577, P=0.677	No relation
	Q3	FET=5.451, P=0.651	No relation
Age	Q2	FET=14.992, P=0.479	No relation
	Q3	FET=41.617*, P=0.280	No relation
Religion	Q2	FET=15.314, P=0.435	No relation
	Q3	FET=29.912, P=0.951	No relation
Education	Q2	FET=10.566, P=0.655	No relation
	Q3	FET=37.014, P=0.157	No relation
Employment	Q2	FET=4.290, P=0.666	No relation
	Q3	FET=14.511, P=0.431	No relation
Software proficiency	Q2	FET=10.474, P=0.286	No relation
	Q3	<b>FET=31.563, P=0.048</b>	<b>There is relation</b>

\*Monte Carlo estimates using 10000 sampled tables was used

religious beliefs (44.4%) rated the statement as **neither important nor unimportant**.

For statement 5, many Christian (34.5%) and Muslim (36.1%) participants found it **very important**, and most Hindu participants (38.9%) rated it as **important to equality**. Participants with other religious backgrounds scored a tie between **neither important nor unimportant** and **slightly important** to software equality with 23.1%. While 33.3% of those who preferred not to disclose their religion rated statement 5 as **not important**.

We observe that both of these statements are related to time, and previous research has demonstrated that there is a correlation between time valuation and cultural factors [39] [40]. Thus, it is likely that this relationship is a demonstration of such a cultural, time-related influence.

## V. THREATS TO VALIDITY

To discuss validity of findings, we consider internal and external validity factors.

### A. Internal Validity

The study design has a large role to play in ensuring that the results correctly convey the information contained in the study data. With this respect, internal validity of this study could be threatened if the statements in Q1 and goals in Q2 are poorly related to the equality concern. Though this threat cannot be fully eliminated we have mitigated it as we have ensured that the equality statements and goals are representative and are closely related to concerns expressed in requirements specifications from several independently defined software system requirements documents.

Although we discussed in Section III-B the reasons of having an unbalanced scale, we note that this could pose a threat to validity if it were to mislead respondents.

We have also used English language survey, which has been filled in by participants from other countries, who are likely to be non-native English speakers. Thus, it is possible that some respondents may interpreted some of the statements differently that they were intended. Yet, as English is the most widely used language for academic research and publications, and the participants would have had access to transition support (e.g.,

via paper and online dictionaries, and translators), we believe this was a reasonable choice to make. In addition, we carried out pilot for the data collection to improve both questions and statements wording and clarity, as well as structure.

### B. External Validity

A threat to external validity can arise if the respondents are not representative of the population [41]. This could have been influenced by the used sampling methods [41] (see section III-C). To ensure that our respondents were representative of different countries, religions, and ages, we posted the survey request internationally and across various age-groups.

Yet, since we used distribution methods (e.g., LinkedIn, Research Gate, etc.) accessible to us, it is likely that some populations with very different views and software use methods would not have been reached. Indeed, we have reported that the *respondents are rather over-educated compared to the expected average set of software users*, as the request for participation was widely posted through university lists and personal requests to university academics.

Moreover, due to the used distribution and data collection format, it was not possible to calculate the response rate. Our respondents are those who volunteered to participant due to some personal interest; clearly not all who got/read the participation requested have completed the survey.

Thus, we must note that the *generality of results presented in this paper relate to the sub-section of well educated, English speaking, and technologically literate software users*.

## VI. DISCUSSION AND CONCLUDING REMARKS

In this paper we presented a survey-based study on perceptions of software users on equality. We investigated if the wider community of software users has a set of “generally agreed upon” equality goals and equality requirements ratings, that should be supported via software. We also looked at whether users’ background characteristics affect they perceptions of equality.

The sample of the respondents to our survey is somewhat skewed, as the respondents are not equally distributed throughout the world regions, and are mainly well educated, English speaking, and technologically literate software users.

The findings here are thus related to this particular sample. Our respondents demonstrated a clear and nearly equal split in their perception of equality goals: roughly a third of them considers equality in terms of equal distribution (what we called *equal equality* in previous discussion), another third perceives it in terms of *unequal equality* whereby each group needs to be treated differently by supporting their own priorities and needs to achieve their own goals. Finally, the last third perceives software equality in terms of more narrowly scoped set of accessibility requirements. While all these topics form part of the present equality discourse, this nearly equal split of priorities was somewhat unexpected. Furthermore, the majority of respondents also indicated that, in order to be conducive for equality, a software system should support the whole wide variety of its user groups.

For the software engineering professionals this means that in order to engineer a software system that is perceived to be conducive to equality characteristic of social sustainability, that system must:

- not only provide accessibility support to all its user groups,
- but also support *unequal equality*, i.e., to ensure that more support is provided to those who need it more, more reward is provided to those who contribute more (i.e., groups are positively differentiated with respect to the goals they want to achieve and support that they need),
- yet the *equal equality* is also observed, whereby despite the differentiated stakeholder goals, all access to resources and services are perceived to be equal and fair.

This, clearly is not an easy task to accomplish, but if either is not upheld, at least one third of the potential user community is likely to be disappointed.

Furthermore, we observe that though there is no unanimous agreement on which requirement statements are most important for equality, there is a general convergence of views that accessibility notions are paramount, closely followed by user diversity support requirements, and then differentiated goal support requirements.

There is also a generic convergence amongst the software users around the notions that are not relevant to equality. Though demographic factors (such a religion and user's experience) affect these perceptions significantly.

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